07-SC-02 Electron Beam Ion Source
Brookhaven National Laboratory, Upton, New York

1. Significant Changes

This is a new data sheet for construction funding beginning in FY 2007. Project engineering and design funding is included for this project in FY 2006 and FY 2007 under project number 06-SC-02.

2. Design, Construction, and D&D Schedule

(fiscal quarter)

	Preliminary Design start	Final Design Complete	Physical Construction Start	Physical Construction Complete	D&D Offsetting Facilities Start	D&D Offsetting Facilities Complete
FY 2007.....	1Q FY 2006	4Q FY 2007	2Q FY 2007	2Q FY 2010	N/A	N/A

3. Baseline and Validation Status

(dollars in thousands)

	TEC	OPC, except D&D Costs	Offsetting D&D Costs	Total Project Costs	Validated Performance Baseline	Preliminary Estimate
FY 2007	13,700	1,100	N/A	14,800[a]	4Q FY 2006[b]	14,800[a]

4. Project Description, Justification, and Scope

This data sheet requests construction funding for the Electron Beam Ion Source (EBIS) project at Brookhaven National Laboratory (BNL). Project engineering and design (PED) funding is included for this project in FY 2006 and FY 2007 under project number 06-SC-02.

The flagship user facility at BNL is the Relativistic Heavy Ion Collider (RHIC), unique in the world for its ability to create a heretofore-unknown state of nuclear matter called quark-gluon plasma. The operation of RHIC supports the scientific mission of the DOE by providing a world-class facility for Nuclear Physics Research. The quark-gluon plasma is created through the collision of heavy ions accelerated to nearly the speed of light. This process is started at the RHIC pre-injector. The present pre-injector for heavy ions for RHIC uses the Tandem Van de Graaff, built around 1970. The beam is transported to the Booster via an 860 m long line.

The EBIS project will provide a new heavy ion pre-injector for RHIC based on a high charge state heavy ion source, a Radio Frequency Quadrupole (RFQ) accelerator, and a short Linear Accelerator (Linac). The highly successful development of an Electron Beam Ion Source at BNL now makes it possible to replace the present pre-injector that is based on electrostatic Tandems with a reliable, low maintenance Linac-based pre-injector.

---

[a] The costs presented in this Project Data Sheet are preliminary estimates and should not be construed as a project baseline, and includes the costs for PED from project 06-SC-02. The Total Estimated Cost (design and construction), established at Critical Decision 0, ranged between $12,000,000 and $17,500,000; the Total Project Cost (design and construction) ranged between $16,000,000 and $19,500,000. NASA is contributing $4,500,000 to the estimated TPC of $19,300,000, thereby reducing the DOE contribution to $14,800,000.

[b] No construction funds will be used until the Performance Baseline has been validated.

Linac-based pre-injectors are presently used at most accelerator and collider facilities with the exception of RHIC, where the required gold beam intensities could only be met with a Tandem until the recent EBIS development. EBIS produces high charge state ions directly, eliminating the need for two stripping foils required with the Tandem. Unstable stripping efficiency of these foils is a significant source of luminosity degradation in RHIC. The high reliability and flexibility of the new Linac-based pre-injector will lead to increased integrated luminosity at RHIC and is an essential component for the long-term success of the RHIC facility. This new pre-injector based on an EBIS also has the potential for significant future intensity increases and can produce heavy ion beams of all species including uranium beams and could also be used to produce polarized ^{3}He beams.

The new RFQ and Linac are used to accelerate beams from EBIS to an energy sufficient for Booster injection. Injection into the Booster will be at the same location as is used for beams from the Tandem.

The new pre-injector will be installed in the lower equipment bay of the existing 200 MeV Linac Building. Modifications to this building will be required to provide an injection path into the Booster and house the new equipment.

In summary, the proposed new pre-injector offers the following advantages:

- The EBIS replaces the 35 year old Tandems with a modern, linac-based pre-injector
- The RFQ and linac technology is simpler, more modern and robust, and will require significantly less effort to maintain.
- The 860 meter long Tandem-to-Booster transport line will be replaced with a 30 to 40 meter transport system
- The EBIS eliminates current limitations on ion species. While injection from the Tandems must start with negative ions, the EBIS can produce any ion species.
- The single EBIS would allow pulse-to-pulse switching between any two species. This increased flexibility will provide the ability to meet the multiple, simultaneous needs of RHIC, NASA, and the Alternating Gradient Synchrotron (AGS). Presently, two tandems are needed for fast beam switching, while the new pre-injector will be able to switch species on a pulse-to-pulse basis.
- Beam stability will be improved with the elimination of stripping foils now required in the tandems.
- The addition of the EBIS pre-injector has the potential to reduce operations costs. The Tandem facility requires a staff of ~12 FTE's to support maintenance and a 24-hour shift rotation during operations. The linac-based pre-injector will run unattended at most times, as with the present proton linac, and will require a staff of ~3 FTE's to maintain.

If the new linac-based pre-injector is not built, upgrades to the Tandems will be required in order to ensure reliable long term operation for RHIC. Construction began for the Tandem Van de Graaff facility in 1966, and it was commissioned in 1970. Many of the Tandem systems are still 1960's technology, and those systems need to be modernized. Obsolete equipment would need to be replaced, and a computer-based control system installed. In addition, sufficient spares for some key components, such as accelerator tubes, would need to be purchased. The estimated fully-burdened cost of these required upgrades is ~$9,000,000. However, the retention, maintenance and modernization of the Tandem system would not provide the advantages of EBIS listed above.

The Electron Beam Ion Source (EBIS) project received CD-0 approval in the 4Q FY 2004 and CD-1 was approved in the 4Q FY 2005. Cost estimates have been improved through a recent bottoms-up cost estimate, an external technical review of the project, which was held in January 2005, and an internal

cost review held in February 2005. A DOE review of technical scope, cost, schedule and management was held in July 2005 prior to CD-1 approval.

The replacement of the existing ion source at Brookhaven National Laboratory (BNL) with the proposed EBIS offers additional capabilities to NASA in the operation of the NASA Space Radiation Laboratory (NSRL) at BNL. NASA is providing a total of $4,500,000 in funding, reducing the Total Project Cost of EBIS to DOE, in order to accelerate the project profile and decrease project duration. The Critical Decision Schedule shown below reflects the accelerated schedule in comparison to that proposed at CD-0.

Compliance with Project Management Order

The project will be conducted in accordance with the project management requirements in DOE Order 413.3 and DOE Manual 413.3-1, Program and Project Management for the Acquisition of Capital Assets. The project costs presented in this data sheet are preliminary estimates for project engineering design and construction. The performance baseline is expected to be validated by the 4Q FY 2006. No construction funds will be used until the Performance Baseline has been validated. The preliminary schedule for project Critical Decisions is as follows:

- Critical Decision – 0: Approve Mission Need—4Q FY 2004
- Critical Decision – 1: Approve Preliminary Baseline Range—4Q FY 2005
- Critical Decision – 2: Approve Performance Baseline—4Q FY 2006
- External Independent Review Final Report—4Q FY 2006
- Critical Decision – 3: Approve Start of Construction—1Q FY 2007
- Critical Decision – 4: Approve Start of Operations—2Q FY 2010

Critical Decision 2 establishing the Performance Baseline is planned for 4Q FY 2006. No construction funds will be used until the Performance Baseline has been validated. The project schedule is being accelerated in order to realize cost savings in RHIC operations sooner and to take advantage of NASA's contributions to reduce the total cost of the project to DOE. NASA funding contributions are intended to complete the project in a more timely manner, consistent with NASA mission requirements.

5. Financial Schedule

	(dollars in thousands)		
	Appropriations	Obligations	Costs
Design/Construction by Fiscal Year			
Design			
2006	1,980[a]	1,980	1,900
2007	120[c]	120	200
Total, Design PED (06-SC-02)	2,100	2,100	2,100
Construction			
2007	7,400	7,400	5,800
2008	4,200	4,200	4,900
2009	—	—	900
Total, Construction	11,600	11,600	11,600
Total DOE TEC	13,700	13,700	13,700

6. Details of Project Cost Estimate

Total Estimated Costs

	(dollars in thousands)	
	Current Estimate	Previous Estimate
Preliminary and Final Design (PED 06-SC-02)	2,100	3,500
Construction Phase		
Site Preparation	695	N/A
Equipment	8,360	N/A
Contingency	2,545	N/A
Total, Construction	11,600	N/A
Total, DOE TEC	13,700[b]	N/A

Other Project Costs

	(dollars in thousands)	
	Current Estimate	Previous Estimate
Conceptual Planning	200	200
R&D	500[c]	—
Start-up	250	—
Contingency for OPC other than D&D	150	—
Total, DOE OPC	1,100	200

[a] The FY 2006 PED funding was reduced by $20,000 as a result of the FY 2006 rescission. This reduction is restored in FY 2007 to maintain the TEC and project scope.
[b] NASA is proposing to provide an additional $3,900,000 in TEC construction funding.
[c] NASA is proposing to provide an additional $600,000 in OPC funding.

7. Schedule of Project Costs

(dollars in thousands)

	Prior Years	FY 2007	FY 2008	FY 2009	FY 2010	FY 2011	Outyears	Total
TEC(Design)	1,900	200	—	—	—	—	—	2,100
TEC (Construction)	—	5,800	4,900	900	—	—	—	11,600
OPC Other than D&D	800	—	100	200	—	—	—	1,100
Total, Project Costs	2,700	6,000	5,000	1,100	—	—	—	14,800

8. Related Operations and Maintenance Funding Requirements

Start of Operation or Beneficial Occupancy (fiscal quarter)	2Q FY 2010
Expected Useful Life (number of years)	25
Expected Future start of D&D for new construction (fiscal quarter)	1Q FY 2035

(Related Funding Requirements)

Costs to operate EBIS are included in the RHIC Operations budget and they are not considered incremental costs.

9. Required D&D Information

This upgrade project will not create any new building square footage, and thus is not subject to the "one-for-one" replacement requirement.

10. Acquisition Approach

The Acquisition Strategy was approved in 4Q FY 2005 with CD-1 approval.